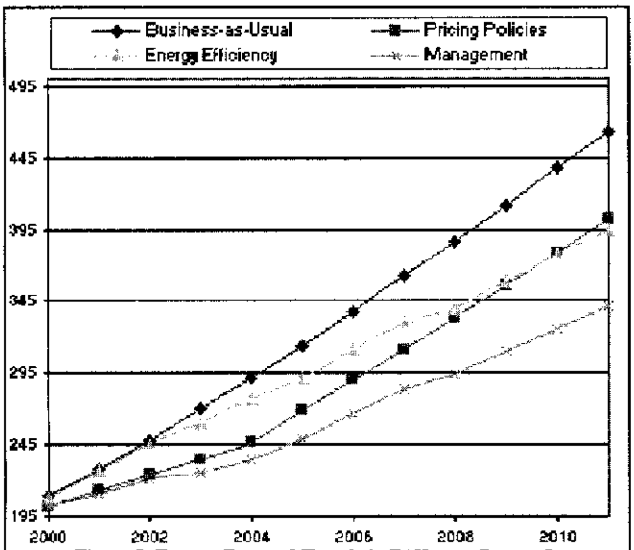


Figure 5. Energy Demand Trends in Different Cases of Base Scenario

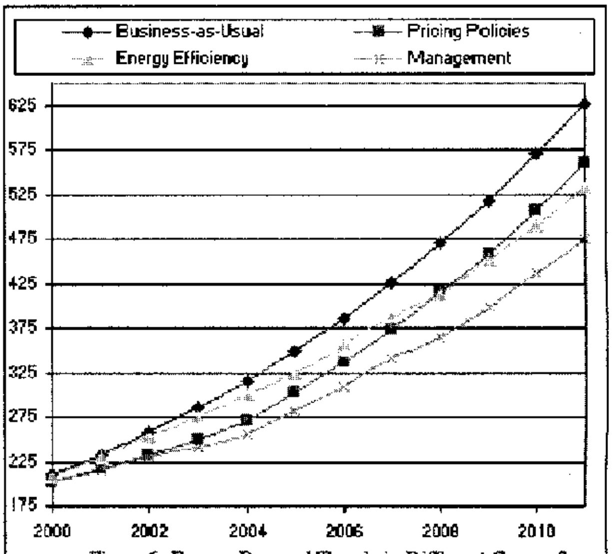


Figure 6. Energy Demand Trends in Different Cases of High Scenario

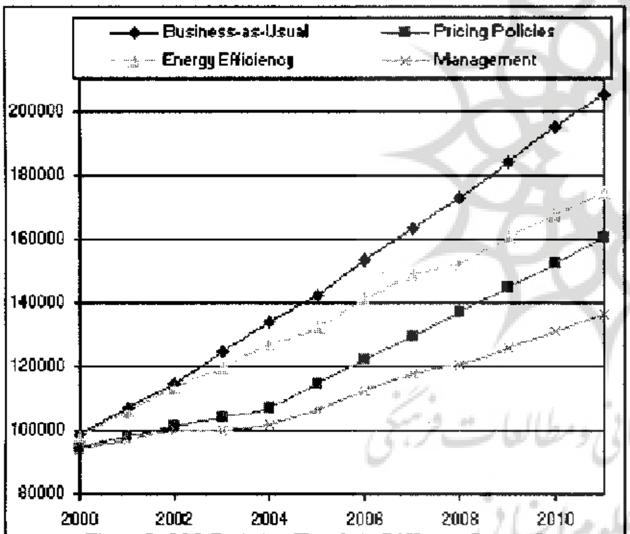


Figure 7. CO_2 Emission Trends in Different Cases of Base Scenario

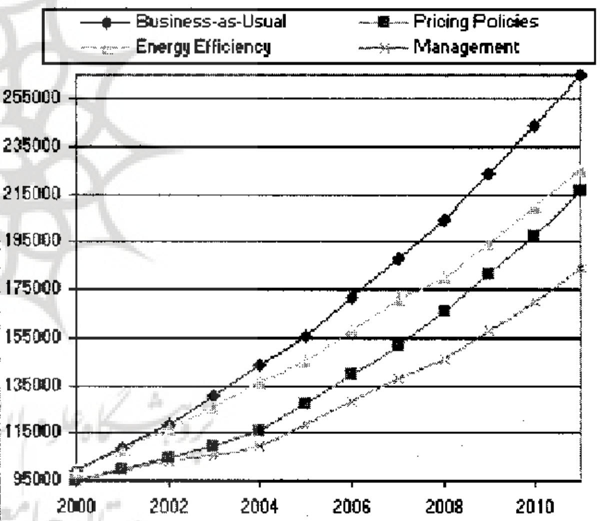
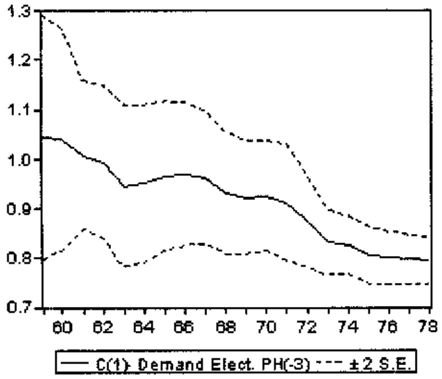
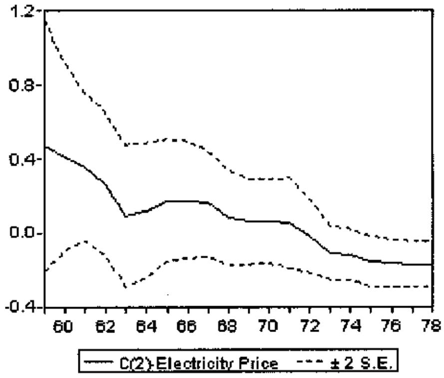


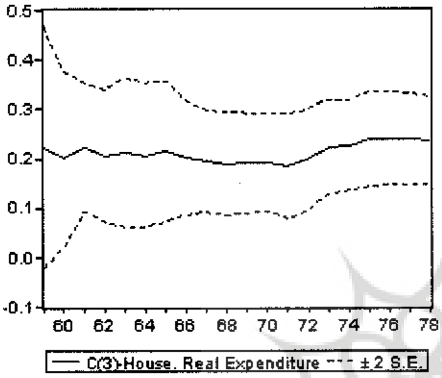
Figure 8. CO_2 EmissionTrends in Different Cases of High Scenario

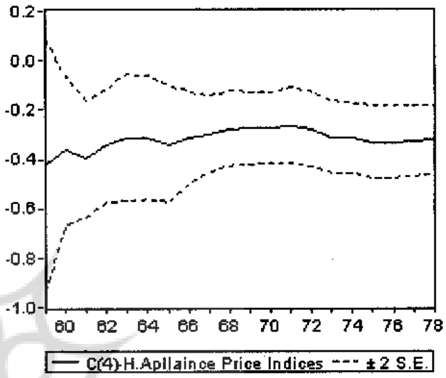
Table 1. ELASTICITY OF VARIABLES IN CEM MODEL

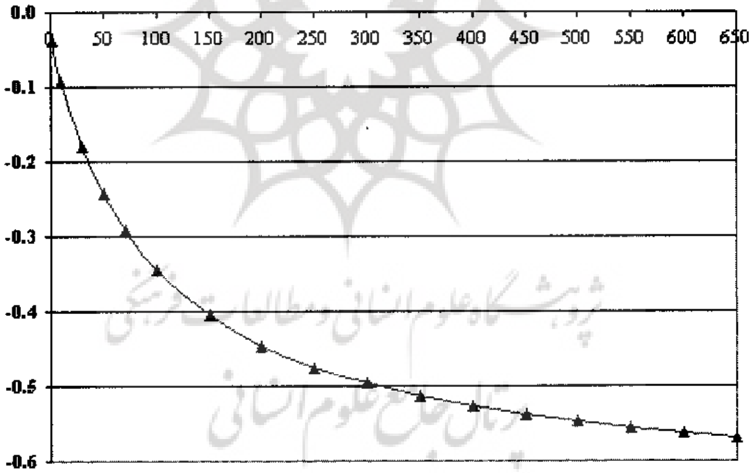
Variable	Short-run elasticity	Long-run elasticity
Price	-0.1768	-0.854
Income/expenditure	0.2348	1.134
Home appliance price index	-0.3239	-1.565











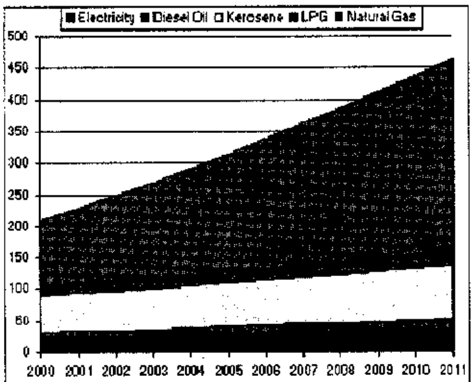


Figure 3. Energy Carriers Demand in Base Scenario with Case of Business-as-Usual (MBOE)

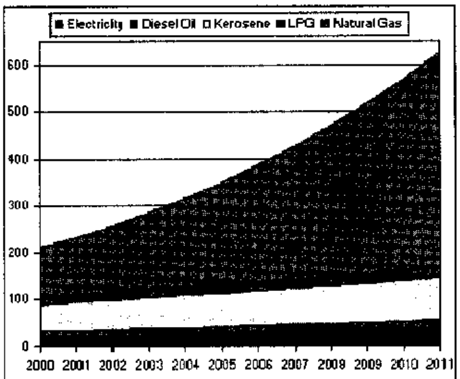


Figure 4. Energy Carriers Demand in High Scenario with Case of Business-as-Usual (MBOE)

with inflation rate. On the other hand, by the end of 2010 the half of existing home appliance will be replaced with new home appliance that 35% efficient. The achievable market potential for efficiency improvement has evaluated by End-use modeling (LEAP Software) and thus the result of energy efficiency potential has been fed to econometrics baseline demand results. Table (2) shows the energy intensity and average hour used of current home appliance and Table (3) shows the potential of energy saving in household sector in the country.

3.2 Results

The results are shown in the figure 2 till figure 10. Figure 3 and figure 4 show that the energy demand in Base and High scenarios with case of BAU increase from 208.9 MBOE in 2000 to 463.6 and 625.8 MBOE in 2011, respectively. Whereas, in Base and High scenarios with case of Management, the energy demand increase from 208.9 MBOE in 2000 to 341.5 and 475.6 MBOE in 2011, respectively. This means that the aggregated impact of fuel pricing and efficient home appliances will be cause the energy carriers consumption till 2011, has been conserved about 122.1 and 150.2 MBOE in Base and High scenarios, respectively. The same results for CO2 and SOX emission trends are shown in figure (7) till figure (10).

4. CONCLUSION

The highly subsidized energy carriers on one hand, and young population of the country on the other hand, caused rapid increase in energy demand in recent years. Although in recent years population growth decreased from 2.7 % to 1.6%, but household growth rate is still very high (2.82%). So that modeling results show an increase in energy demand from 208.9 MBOE in 2000 to 463.6 MBOE in 2011, i.e. 6.8% annually in Base scenario with case of BAU. Similarly, the CO2 emissions in Base scenario with case of BAU increase from 98.7 Mtons to 205.3 Mtons. In the case that in Base scenario with case of pricing policy the energy demand and CO2 emissions reach from 208.9 MBOE and 98.7 Mtons in 2000 to 401.7 MBOE and 160.6 Mtons in 2011, respectively.

Although, this results seem exaggerated, but in Iran for 1000 US$ added value in GDP, energy consumption, is 11 times more than Japan, 3.25 times more than Korea and 1.58 times more than Indonesia (IEA, 2001). Therefore with regards to international challenges against global warming and with respect to the commitments of countries undertaking United Nations Framework Convention on Climate Change (UNFCCC) for abetment of GHGs, on one hand, and prevention of energy resource waste, on the other hand, it would be essential to set a comprehensive policy for fuel price, de-subsidizing and energy efficiency programs in the context of the country.

REFRENCESS

Ahadi, M.S., Davoudpour, H., Electricity Pricing in Household Sector and Its Impact on Greenhouse Gases Mitigation, The 7th Annual International Conferences of Industrial Engineering, Busan, Korea, October, 24-26 2002, pp 498-501.

Chapman, L.D., Mount, T.D., Tyrrell, T.J., Electricity Demand in United State: An Econometrics Analysis, Proceedings for Energy Demand, Conservation and Institutional Problems Conference, MIT, USA, Feb. 1973, pp 319-328.

IEA, International Energy Agency, Key World Energy Statistics, IEA Publishing Center, Paris, 2001.

IPCC, Intergovernmental Panel on Climate Change, Guidelines for GHG's Emission Inventory, 1996 Revised, Vol. 1,2,3.

Jannuzzi, G.M., Swisher, J.N., Tools and Methods for Integrated Resource Planning, UNEP Collaboration Center on Energy and Environment and RISO National Laboratory, Denmark, November 1997.

Nagel. R., Vob, S., Energy Model for Planning and Policy Assessment, European Journal of Operation Research, Vol. 8,pp 99-114, 1981.

Saboohi, Y., Energy Systems: Planning Methodologies and Models, Sharif University of Technology, Tehran, Iran, May 2000.

variables. For de-trending of variables, per household assessment was applied. The result as follows:

Constant elasticity model

Ln(Demand_Elect_PH)=0.7930* Ln(Demand_Elect_PH(-3))- 0.1768*Ln(Price_Elect)+0.2348* Ln(Hous_Real_Expenditure) - 0.3239*Ln(HAp_Price_Index) (11)

Where:

Demand_Elect_PH = Per household electricity demand (BOE/h) in year (t)

Demand_Elect_PH(-3) = Per household electricity demand(BOE/h) in year (t-3)

Price_Elect = Deflated price of electricity (Rial/kWh)

Hous_Real_Expenditure = Household real expenditure/income (Deflated -Thousand Rial/h)

HAp_Price_Index= Deflated price index of home appliance

Table (1) shows the result for elasticity of variables in electricity demand function. The regression analysis of the electricity consumption shows the following results:

The 99% variation of explanatory variable is explorer with independent variables (R2adj= 0.99)

The total electricity demand's elasticity less than unit ($\sum \beta i = 0.53$)

The income and price elasticities are 0.23 and -0.18, respectively. Furthermore 10% growth in household income and real electricity price caused 0.5% growth in electricity demand in household sector. Indeed the pricing policies of the government in third five years development plan (FYDP) is not effective in demand reduction.

The recursive coefficients test (stability test) shows that expand range in context of observed data. Furthermore the CEM model cannot to make accurate projection on future demand (figure 1).

For this purpose the variable elasticity model (VEM) are recommended as follows:

Variable elasticity model

Ln(Demand_Elect_PH) = 0.7617* Ln(Demand_Ele ct_PH(-3))

0.6492*Ln(Pr ice_Elect)+0.1186* Ln(Hous_ Re al_Expenditur e)

-1.2088/ (Pr ice Elect) +32.14/ (HAP_Pr ice_ Index) (12)

Where:

Demand_Elect_PH, Price_Elect, etc. has defined in Equ. (1).

Figure 2 shows that 250% increase in electricity price in short-run resulted in the price elasticity change from -0.04 to -0.475. This means that if the electricity price changes from 1.98 Rial/kWh to 6.93 Rial/kWh, the pricing policy 12 times effective in demand reduction (Ahadi, 2002).

3. IMPACT OF PRICING POLICIES AND EFFICENCY IMPROVEMENT ON ENERGY CARRIERS DEMAND, GHGs AND AIR POLLUTANTS EMISSION IN HOUSEHOLD SECTOR

3.1 Definition of Scenarios and Assessing Energy Efficiency Potential

For assessing the impact of price and applying efficient home appliance on energy demand two scenarios with two cases were developed. For GHGs and air pollutants emission estimation the IPCC, 1996 emission factors were used. The definitions of these scenarios and cases as follow:

Base scenario: In this scenario the real income of household and deflated home 0appliance price index are constant.

High scenario: This scenario supposed that the household real income and deflated home appliance price index between 2000 and 2010 increase 8.3% and decrease 7.8 %, respectively.

Case of business-as-usual (BAU): In this case the nominal fuel price increase annually with inflation rate (deflated price is constant) and any changes do not happen in energy intensity and consumers' pattern.

Case of management: This case supposed that the fuel price increase to total price by the end of third FYDP (2004) and after 2004, it is increase

$$\alpha = \frac{\Delta E/E}{\Delta Y/Y} = \frac{\%\text{ change in energy demand}}{\%\text{ change in income}}$$

$$\beta = \frac{\Delta E/E}{\Delta E/P} = \frac{\%\text{ change in energy demand}}{\%\text{ change in energy price}}$$

Where:

α, β= Constant elasticity of income and price and E, Y, P has been defined in Equ. (1),

α, β In the aforementioned equations show the short-run elasticity, but the long-run elasticity is defined as:

$$\alpha_L = \frac{\alpha}{1-\gamma}$$

$$\beta_L = \frac{\beta}{1-\gamma}$$

Where:

α_L, β_L = Long-run constant elasticity of income and price, and has been defined in Equ. (1),

In several cases because of expand range of historical data (time series data), the Constant Elasticity Models (CEM) cannot to accurate projection for energy demand, in this cases the Variable Elasticity Models (VEM) have been revealed better forecasting and are defined as:

$$E_t = \alpha \times Y_t^{\alpha} \times P \times \exp(\lambda + \theta/Y_t + \eta / P_t)$$

(6)

Where:

E_t, P_t, Y_t, E_{t-k} has been defined in Equ. (1),

η, θ, λ, γ , β, α, a Are coefficient (it is to be noted that the in Equ. (6) are not the income and price elasticity)

In VEM models the short-run and long-run elasticity of income and price are defined as:

(4)

$$\alpha s = \alpha - \frac{\theta}{Y}$$

$$\beta s = \beta - \frac{\eta}{\rho}$$

$$\alpha L = \frac{\alpha s}{1-\gamma}$$

$$\beta L = \frac{\beta s}{1-\gamma}$$

Where:

α_S , β_S = Short-run variable elasticity of income and price

α_L, β_L = Long-run variable elasticity of income and price

The econometric approach utilizes past data to statistically estimate (by means of regression analysis, for example) the parameters a, and in Equ. (1). Econometric models were widely used in energy demand forecasting. They are still important tools to understand of the aggregate nature of energy demand and its determinants. However, the fundamental assumption of this model is that the relationship between income, price, and demand, which existed in the past, will continue to hold in the future. The more fundamental structure of energy demand is not analyzed, and the model's predictive capability breaks down if this fundamental structure changes. There is increasing evidence showing that this relationship between energy, income and prices may very significantly in the future when important changes in technological structure of energy demand, consumer behavior, etc. are taking place.

One application of econometric modeling that is useful for energy-efficiency projections, however, is the projection of baseline energy-service growth. If the technological structure of energy demand remains constant, including the end- use efficiency, then the projected growth in energy consumption is identical to the growth in energy services.

This type of projection is also referred to as a "frozen- efficiency" scenario.

2.2 Energy Carriers' Demand Functions

According to studies carried out by Chapman (1973), fundamental of electricity demand function in household sector based on relationship between population, income, price of electricity and substituted energy carries and electric home appliance price indices. In Iran, because of high rate of population growth in recent years (2.7-1.6%) and thus exponentially growth trend of electricity demand (6.5% annually) caused the non-stationary-trend behavior for explanatory

MBOE to 401.7 MBOE. In the case that, the energy efficiency program to be implemented, energy carriers demand in 2011 in BAU case of base scenario to be reduced from 463.7 MBOE to 394.1 MBOE.

Similarly, in the BAU case of base scenario, the CO2 emission increases from 98,737 Ktons in 2000 to 205,304 Ktons in 2011 with annual growth rate of 6.3%. In comparison, if the fuel price is increased it will cause the CO2 emission in 201 to be reduced from 205,304 Ktons to 160,590 Ktons.

Keyword: Demand Function, Pricing Policy, Greenhouse Gases Mitigation, Energy Planning, and Efficiency Improvement.

1. INTRODUCTION

The young population of the country and their needs for employment caused an up going rate in energy carriers' consumption. Therefore regarding the limit fossil energy resources on one hand, and adverse impact of energy sector development and fuel consumption on environment, on the other hand, required to comprehensive analysis of interaction between energy, economy and environment. For rational energy uses, determination of the magnitude of the relationships between the energy carriers quantity and causal factor such as fuel price is very important, because the energy prices has an important role in efficient consumption of energy carriers. The main objective of this paper focused on assessing the impact of fuel price on demand and GHGs emission reduction.

2. MODELS FOR PROJECTION OF ENERGY CARRIERS DEMAND

For projection of energy carriers demand, several models and methodologies are used (Saboohi, 2000). These are:

Trend analysis
- Econometrics models
- Econometrics market models
- Econometrics process models
- Ad hock econometrics models

Input - output models
Intelligent systems (Neural network)
End use modeling

Each of these models has various advantages and disadvantage and applied for different purposes. For example the neural networks are applied for short-run demand and peak load projection in small scale, whereas the input-output models are applied for national economy level demand analysis with higher degree of aggregation.

Econometrics models were widely used in energy demand projection up to 1970s. But, recent years because of fast technology changes, econometrics models only applied for baseline projection (Nagel, 1981).

2.1 Econometrics Models

Econometrics models have the advantage of requiring less data than other models such as engineering-oriented models and have a good theoretical statistical base. Usually they are used for a whole class of customers and do not take into account the technological structure of their energy consumption. Thus, they have a more aggregate nature than the engineering-oriented end-use approach (Jannuzzi, 1997).

The most common type of econometric equation used in energy studies is based on the Cobb-Douglas production function:

$$E_t = a \times Y_t^{\alpha} \times P_t^{\beta} \times E_{t-k}^{\gamma} \qquad (1)$$

Where:

E_t = Energy demand in year (t),
Y_t = Income in year (t),
P_t = Energy price in year (t),
E_{t-k} = Energy demand in year (t-k),
α, γ = Constant,
α, β =Income and price elasticities of demand,

Income and price elasticities indicate how the demand for energy changes as result of changes in prices and incomes in econometric models. Income and price elasticities are defined as:

Assessing the Impact of Fuel Pricing and Efficiency Improving on Energy Carriers Consumption and GHGs Mitigation in Residential Sector of Iran

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Abstract:

This paper evaluates the impact of fuel pricing and application of the efficient home appliance on GHGs emission reduction in household sector of the country. For this purposes, the Demand Functions for energy carriers in household sector has developed by econometrics models.

The stability test for variables' coefficient shows that the demand functions with constant price elasticity are not suitable for Demand Forecasting and Policy Making in the country. Furthermore, econometrics demand functions with Variable Elasticity were also developed.

The results reveal that the price elasticity for electricity demand in Constant Elasticity Model (CEM) for Short-run and Long run is -0.142 and -0.901, respectively. In the Variable Elasticity Model (VEM) the 250% increase in the electricity price in Short-run resulted in the price elasticity change from -0.02 to -0.475, hence the 250% increase in electricity price in Long-run resulted in the price elasticity change from -0.15 to -2.0[2].

Finally, with help of Scenario Based Approach the impact of fuel pricing and applying efficient home appliance intrends of GHGs emission was assessed in Scenarios Base and High, developed on two different cases of Business-as-Usual and Management. For assessing the impact of energy efficiency on GHGs emission mitigation, achievable market potential for efficiency improvement has evaluated by End-use modeling (LEAP3). The results indicate that the energy carriers demand in the BAU case of base scenario increases from 208.9 MBOE (million barrel of oil equivalent) in 2000 to 463.6 MBOE in 2011with annual growth rate of 6.8%. Comparatively, if the energy carriers' price is increased to total price (except for natural gas) it will cause the energy carriers demand in 2011 to be reduced from 463.6